Department for Work and Pensions

Department for Work and Pensions Social Security Administration Act 1992

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*Presented to Parliament by the Secretary of State for Work and Pensions*
*By Command of Her Majesty*
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ISBN: 9780101744027

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## INDUSTRIAL INJURIES ADVISORY COUNCIL

***Secretary of State for Work and Pensions***

Dear Secretary of State,

**REVIEW OF OSTEOARTHRITIS OF THE KNEE IN COAL MINERS**

We present our report which considers prescription for osteoarthritis of the knee in miners. Osteoarthritis of the knee, a common disorder in the general population, was last reviewed by the Council in May 1995 in its Command paper 'Disorders of the Knee' (Cm. 2842). This report follows a representation from an ex-Council member highlighting epidemiological evidence of an increased risk of this disorder in miners.

During the course of our review we have considered the relevant research literature, made calls for evidence and consulted with experts in the field. We have identified direct research evidence of a greater than doubled risk of osteoarthritis of the knee in miners and indirect evidence of an excess risk of the disorder associated with occupational kneeling and squatting while undertaking heavy manual tasks (such as lifting or shovelling), activities traditionally undertaken by miners. The evidence suggests that the qualifying excess risk would arise after 10 or more years in aggregate of everyday occupational kneeling or squatting while undertaking heavy physical manual work.

The coal mining industry has undergone many changes which have decreased the extent to which miners have been exposed to such employment conditions, notably the closure of many mines by 1986. However, we have received evidence that the relevant exposure circumstances will still have occurred after 1986 in certain categories of miner, such as faceworkers working non-mechanised coal faces.

We recommend that osteoarthritis of the knee should be prescribed in relation to work as an underground miner for ten years or more in aggregate; but that to be reckonable, any service from 1986 onwards should be in certain specific categories of coal mining occupation, as set out in the recommended prescription schedule.

Yours sincerely

Professor K Palmer

*Chairman*
July 2008

## Summary

1. Osteoarthritis of the knee is a common disease in the general population, especially at older ages. The disease is characterised by destruction of the cartilage surrounding the knee joints and various alterations to the bone and the joint space between bones, and the main symptoms include knee pain, knee swelling, stiffness and reduced mobility. Osteoarthritis of the knee can be a significant cause of disability, sufficient in advanced cases to require surgical knee joint replacement.

2. Coal mining is traditionally a physically demanding occupation associated with prolonged and frequent heavy lifting, kneeling and squatting. Such activities can lead to osteoarthritis of the knee through wear and tear and prolonged physical stresses on the knee joint, or via injury to the knee cartilage (meniscus), which in turn renders the joint more vulnerable to wear and tear. Osteoarthritis of the knee, if arising in consequence of a discrete accident, will be covered by the Accident Provisions of the Industrial Injuries Disablement Scheme. However, evidence suggests that both osteoarthritis of the knee and meniscal injuries may be more common in miners, even in the absence of documented accidental events.

3. This review considers the case for prescription for osteoarthritis of the knee in miners from wear and tear or meniscal injuries outwith accidental events. Our inquiry follows a representation from an ex-Council member highlighting research evidence of an increased risk of the disease in miners. During the course of the review, the Council undertook its own literature search, made a call for evidence, and consulted with experts in the field and representatives from the coal mining industry.

4. The Council identified two high quality, well conducted studies from the 1950s which clearly showed a greater than doubled risk of osteoarthritis of the knee in miners. Supporting this relatively limited direct evidence, was a wealth of more recent indirect research evidence, which showed that kneeling or squatting under heavy physical load – a common occupational circumstance of mining – was also associated with a greater than doubled risk of knee osteoarthritis.

5. Evidence from several studies suggested that the excess risk of disease might be expected where such exposures arose over a time period of at least 10 years in aggregate.

6. Coal mining has seen dramatic changes between 1947, when the industry was nationalised, and 1986, when the majority of British coal mines closed. During this period, such factors as the mechanisation of mining processes, declining demand for coal, and an industry trend towards mining of thicker

(more profitable) seams, led to a significant decrease in the amount of time most miners spent kneeling and squatting while undertaking heavy physical tasks. However, evidence the Council has received indicates that such activities would still have been undertaken by certain categories of miner well after the mid-1980s.

7. The Council recommends that osteoarthritis of the knee should be prescribed in relation to work as an underground miner for ten years or more in aggregate; but that to be reckonable, any service from 1986 onwards must be in one or more of the following categories: as (a) a faceworker working non-mechanised coal faces; or (b) as a development worker or conveyor belt cleaner or attendant.

## INTRODUCTION TO THE REVIEW

8. IIAC received representations from an ex-Council member to consider osteoarthritis of the knee in miners. The ex-Council member had been involved in providing expert evidence during a medicolegal case and provided an appraisal of key research papers. (The Council also received representations concerning osteoarthritis of the knee in professional footballers, which will be considered at a later date.)

9. Industrial Injuries Disablement Benefit (IIDB) can be paid under two circumstances: either where an occupational accident has occurred or where an individual has developed a 'prescribed' disease out of the course of their employment as an employed earner. The accident provisions of the IIDB scheme cover not only the immediate, short-term disabling effects of the accident, but also those that may not develop until many years after the original accident. Identifiable incidents leading to OA knee may be accepted under the accident provisions of the Scheme.

10. Osteoarthritis is a common disease in the general population. IIAC has already published its review of osteoarthritis of the hip joint ('Osteoarthritis of the hip', November 2003, Cm. 5977), recommending it should be a prescribed disease for farmers. This investigation is concerned with ascertaining whether osteoarthritis of the knee in miners could be added to the list of prescribed diseases for which IIDB is payable.

### The Industrial Injuries Disablement Benefit Scheme

11. The Industrial Injuries Disablement Benefit (IIDB) scheme provides a benefit that can be paid to an employed earner because of an occupational accident or prescribed disease. The benefit is 'no-fault', tax-free, non-contributory and administered by the Department for Work and Pensions. It is paid in addition to other incapacity and disability benefits, but is taken into account when determining the level of payment for income-related benefits.

### The Role of the Industrial Injuries Advisory Council

12. IIAC is an independent statutory body established in 1946 to advise the Secretary of State for Social Security on matters relating to the IIDB Scheme. IIAC has three roles:

- To advise on the prescription of occupational diseases.
- To advise on matters referred by the Secretary of State. Draft regulations or proposals concerning the IIDB scheme must be referred to the Council for consideration and advice, unless they are exempted by law from such reference.

- To advise on any other matter relating to the IIDB scheme or its administration.

  IIAC is non-departmental public body and has no power or authority to become involved in individual cases or in the decision-making process.

**Prescribed disease provisions of the IIDB Scheme**

13. The Social Security Contributions and Benefits Act 1992 states that the Secretary of State may prescribe a disease where he is satisfied that the disease:

a) ought to be treated, having regard to its causes and incidence and any other relevant considerations, as a risk of the occupation and not as a risk common to all persons; and

b) is such that, in the absence of special circumstances, the attribution of particular cases to the nature of employment can be established or presumed with reasonable certainty.

14. In other words, a disease may only be prescribed if there is a recognised risk to workers in an occupation, and the link between disease and occupation can be established or reasonably presumed in individual cases. This is the framework in which IIAC must work when considering the prescription of occupational diseases.

15. Some occupational diseases are relatively simple to verify as the link with occupation is strong. For example, the disease may rarely occur outside work (eg mesothelioma) or have distinctive clinical features when caused by work. On the other hand, where a disease is common in the general population and has no unique clinical features in occupational cases, it is more difficult to establish a presumptive link between the occupation and the disease. An example of this type of condition is osteoarthritis of the knee.

16. Attribution then depends on a probabilistic assessment. Epidemiology is the branch of medicine that deals with the frequency, distribution and determinants of diseases in human populations and IIAC applies epidemiological principles when making probabilistic assessments (‘more likely than not’).

17. In epidemiological terms ‘more likely than not’ corresponds to an “attributable fraction” (i.e. percentage of cases caused by an occupational exposure among those with exposure) that is greater than 50%. Suppose 50 cases of a disease occur in a given group of unexposed workers as the background risk common to everyone in the population under consideration. For the disease to be considered ‘more likely than not’ attributable to a work

exposure, there would have to be at least 50 cases in a similarly sized group of exposed workers, over and above the 50 background cases that would occur as a matter of course. Thus, 'more likely than not' can be thought as a (more than) doubling of risk – a person in a particular job being more than twice as likely to get a disease as someone not in that occupation.

18. In seeking to address the question of prescription for any particular condition, the Council first looks for a workable definition of the disease. The Council then searches for a practical way to demonstrate in the individual case that the disease can be attributed to occupational exposure with reasonable confidence as described above. Accidental exposure at work is specifically catered for within the IIDB scheme. However, if the condition might result from occupational exposure in the absence of an identifiable accident, the Council must consider whether it should be included in the list of prescribed diseases for which benefit is payable.

## Method of investigation

19. In respect of knee osteoarthritis, the Council made a call for evidence in the medical and scientific press in Spring 2007. The Council consulted with experts in the field and performed a detailed literature review, covering evidence both in mining and in activities common to miners. Original papers were retrieved, including a published review focussed on the case for prescription in UK coal miners (McMillan *et al*, 2006) and the report of a review commissioned by the Danish National Board for Industrial Injuries (Jensen 2007).

### Anatomy of the knee

20. The knee joint is a complex joint, formed where the end of the thigh bone (femur) and the top of the leg bone (tibia) meet, and is covered at the front by the knee cap (patella). The knee joint is the largest synovial joint in the body. The synovium is the tissue lining the joint that produces fluid to lubricate and protect the joint surfaces.

21. The joint is cushioned by articular cartilage. In addition, the menisci (C-shaped discs of fibro-cartilage) are interposed between the tibia and the condyles of the femur, helping to increase the area across which load is transmitted through the joint. Ligaments (collateral and anterior cruciate ligament) connect the femur and tibia, and tendons, attach the muscle to the bones, stabilising and supporting the knee. The knee joint is capable of extension and flexion due to the action of the muscles at the front of the thigh (the quadriceps) and at the back of the thigh (hamstrings). A diagram of the knee joint can be seen in Figure 1.

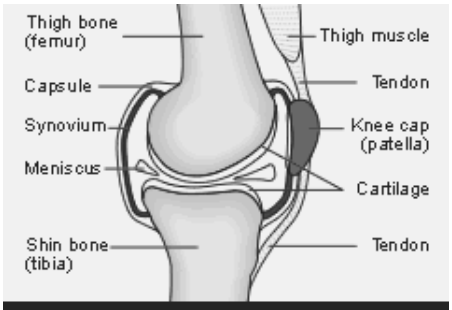

Figure 1. A normal knee joint (side view)

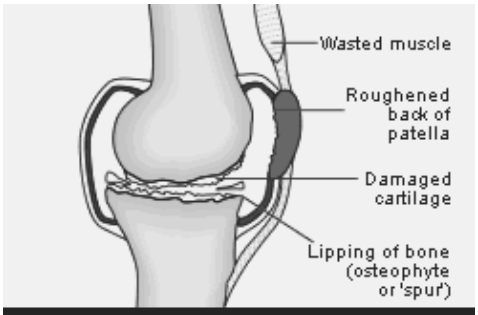

Figure 3. A knee joint with osteoarthritis

*Figure 1. Diagram of a normal knee joint. Figure 2. Diagram of an osteoarthritic joint. Diagram reproduced with permission from the Arthritis Research Campaign.*

## OSTEOARTHRITIS OF THE KNEE

### Clinical and radiological features

22. Knee pain is common in the general population and can be caused by a variety of factors, including osteoarthritis of the knee joint. Knee pain is also common in those without X-ray evidence of arthritis.

23. Osteoarthritis of the knee is a sequence of degradation and destruction of the cartilage surrounding the joints, resulting in exposure of the underlying bone, bone thickening, new bone regeneration, reduction of the bone space and altered biomechanics. A diagram of an osteoarthritic knee joint can be seen in Figure 2. The diagnosis of knee osteoarthritis is supported in individuals with knee pain, swelling, stiffness and limited mobility of the joint and pathological changes on radiographs, such as joint space narrowing, new bone formation and bone thickening. Such changes may be accelerated where the shock-absorbing cartilages of the knee are worn, torn or injured.

24. The radiological and clinical features of osteoarthritis of the knee do not always correlate well. In the NHANES-I study, half of those with osteoarthritis of the knee confirmed by radiograph did not experience pain, while only 15% of those with knee pain had radiological evidence of osteoarthritic pathology. However, the correlation is greater with severe osteoarthritic changes.

25. Treatment options include analgesic and anti-inflammatory medication, physiotherapy, functional aids and surgery. Severe osteoarthritis of the knee may warrant total knee replacement.

### Risk factors for osteoarthritis of the knee

26. A major risk factor in osteoarthritis of the knee is increased age; most people will have some symptoms of osteoarthritis by the time they are 70. Several other factors have been implicated in the development of osteoarthritis

of the knee: heredity factors, female gender, being obese (which is an important risk factor), having a knee injury or a meniscectomy (surgery to remove or repair a tear of the knee cartilage), osteoarthritis occurring in other joints, such as the finger joints, and joint over-use without a specific injury (further discussed below).

## CONSIDERATION OF THE EVIDENCE

27. Coal mining has always been an arduous occupation, with physical demands arising in relation to heavy lifting, kneeling, squatting and crawling. Work at the coal face, in particular, often involves low headroom and prolonged kneeling, and is associated with the well-established hazard of pre-patellar bursitis in miners, scheduled as prescribed occupational disease PDA6. While the trend to increased mechanisation of mines has led to a steady reduction in the physical demands of occupation, frequent kneeling and squatting, and heavier than usual physical work are still general features of work in the industry.

28. In principle, such activities can give rise to osteoarthritis of the knee in one of two ways – (i) by direct wear and tear and physical stresses on the load-bearing joint, sustained over a prolonged interval of time; or (ii) indirectly through meniscal injury, which in turn renders the joint more vulnerable to wear and tear. Tears of the meniscus can be caused by acute trauma to the knee, in particular twisting of the joint while it is flexed, so osteoarthritis of the knee joint is a well-recognised long-term complication of accidental injury to the knee; but some evidence exists that meniscal tears may be more common in coal miners even in the absence of documented accident events.

29. Osteoarthritis of the knee complicating traumatic injury can be compensated under the accident provisions of the IIDB Scheme. Thus, the Council focussed attention on the evidence relating to osteoarthritis in the absence of accidental injury (whether or not associated with meniscal damage).

30. As the clinical features in occupational cases of knee osteoarthritis would not be uniquely distinctive, the Council sought evidence of a more than doubling of risk in miners relative to other occupations, following the logic set out above in paragraph 10.

### Studies of knee osteoarthritis in miners

31. An increased risk of knee osteoarthritis in coal miners has long been suspected. In 1945, the Medical Advisory Committee to the Department of Health for Scotland reported a higher rate of incapacity from “joint group rheumatism” in miners than in other occupations (Medical Advisory Committee (Scotland) 1945), although findings were not specific to the knee.

32. The main direct evidence, however, comprises two studies by Kellgren and Lawrence (1952, 1955) and a study in German by Greinemann (1997).

33. Kellgren and Lawrence (1952) conducted a radiological survey in random samples of 84 miners, 45 non-mining manual workers and 42 office workers aged 40-50 years from Leigh in Lancashire. Their study extended an earlier cross-sectional survey that had shown an excess of knee pain in miners relative to age and sex-matched non-miners from this community. In the follow-up, "severe" radiological osteoarthritis of the knee was found in five (6%) of the miners as compared with one (2%) of the manual workers and none of the office workers. For "slight" radiological osteoarthritis of the knee, the corresponding figures were 34 (40%), 9 (20%) and 10 (24%). Those with radiological change more often had pain and physical signs in the knee.

34. Another study by Lawrence (1955) focussed on aspects of mining responsible for the higher risk of osteoarthritis. This survey covered age-matched face workers, roadway workers, miners from collieries with a greater seam height, miners from a damp colliery, dockers, light manual workers and office workers. Knee pain was generally more common in the miners, except at the colliery with the higher seams. The presence of knee osteoarthritis was assessed by two observers who did not know each subject's occupation. The prevalence of "definite" radiological changes was clearly greater in all of the mining groups (17% of face workers, 36% of roadway workers, 20% of miners from collieries with high seams, 30% of miners from the damp colliery) than in non-miners (11% of dockers, 11% of light manual workers and 7% of office workers).

35. Risk was increased in men known to have had previous knee injury, but this accounted for few of the cases. Kneeling was discounted as a risk factor since the excess was also found at pits with higher seams, but no detailed analysis by occupational activity was made at the individual level. No evidence was found of a relation to heavy lifting or work in wet conditions, but with similar limitations to the evidence base.

36. Greinemann (1997) describes a study in which clinical and radiological examination of both knees was carried out in 500 miners aged 50 years with at least 25 years of work at the coal face, and a similar number of age-matched referents with no sporting or occupational knee strain. Main joint osteoarthritis was diagnosed in 65 (13%) of the miners as compared with five (1%) of the controls. Excesses were also found of retropatellar arthrosis (10.6% vs 3%) and panarthrosis (5.4% vs 0.6%). However, it is unclear how the subjects were selected for study and whether the radiological assessment was carried out without knowledge of the subjects' occupational status (lack of blinding could give rise to a bias in ascertainment). A further weakness of this report is the failure to specify diagnostic criteria – in contrast to Kellgren and Lawrence,

whose classification scheme became a standard for later epidemiological research in knee and hip osteoarthritis.

**Studies of meniscal tears in miners**

37. Several studies of miners suggest that a higher risk of knee osteoarthritis may exist, by indicating they have an increased risk of meniscal injury. Thus, for example, Sharrard and Liddell (1962) abstracted details of occupation from the records of five local hospitals in south Yorkshire in 957 men aged 15-64 years, who underwent surgical removal of a meniscus and compared these with similar details on 1075 men of similar age admitted to the same hospitals for appendicectomy over the same period. The occupation of miner was more common in the meniscectomy group, and overall, the findings suggested that miners aged 25-54 years were 4-5 times as likely to require meniscectomy as other men. In a further analysis from the study by Greinemann (1988) referred to above, a history of surgically treated meniscal injury was four times more common in the miners. Several case series, although providing weaker evidence, point towards the same conclusion.

**Studies in relation to activities commonly found among miners**

38. Further indirect evidence comes from studies that did not investigate miners *per se*, but which focussed on exposures that are likely to be common among miners. The Council's search identified a number of papers with relevant observations, including those by Manninen (2002), Felson (1991), Sandmark (2000), Kivimaki (1992), Schouten (1992), Andersen (1998), Coggon (2000), Lau (2000), Sandmark (2000), Dawson (2003), Vingard (1991, 1992), Cooper (1994) and Jensen (2000, 2005).

**Osteoarthritis of the knee**

39. Evidence seems strongest in relation to kneeling, squatting, and heavy physical work such as lifting with the knees bent.

40. Thus, for example, a British case-control study by Coggon et al (2000) compared 518 patients listed for surgical treatment of knee osteoarthritis with controls from the same communities, matched for sex and age. Histories of occupational activities and knee injury were ascertained at interview. After statistical allowance for body weight, history of knee injury and the presence of markers of hand osteoarthritis , risks were more than doubled in subjects who reported kneeling or squatting at work for more than one hour per day over at least one year and raised 1.7-fold in those lifting weights of 25 or more kg more than10 times per week for at least a year. There was also an association with occupational climbing of ladders and stairs in men (odds ratio 2.3) but not in women. Even greater risks were reported from work that entailed both kneeling/squatting and heavy lifting (OR relative to neither activity 2.9 in men and 4.2 in women).

41. Cooper *et al* (1994) studied over 2000 adults aged 55 years or older from a general practice in Bristol. From answers to a postal survey, they identified people with pain around the knee on most days for at least a month at some time in the past year, who, along with an equal number of pain-negative controls, were invited to undergo interview and X-ray examination of the knee (interpreted blind to symptom history). Those with pain and osteoarthritis of a certain severity were classed as cases, and their exposure to risk factors was compared with that of controls, matched for sex and age, who had no knee pain and little or no osteoarthritis in either knee. Subjects were classified according to the activities in their longest held job prior to the onset of symptoms (cases) or interview (controls). After adjustment for other risk factors, the odds ratio for knee osteoarthritis was 2.5 for those with jobs that entailed kneeling squatting or stair climbing and 5.4 for those who were also exposed to heavy lifting in their work, in comparison with those whose work did not involve any of these factors.

42. Anderson and Felson (1988) used data from the first US National Health and Nutrition Examination Survey to examine associations between knee osteoarthritis on X-ray and various potential risk factors in over 5000 subjects. Current occupation was coded in a standard way, and job categories scored according to their strength demands (from sedentary to very heavy) and whether they entailed knee bending (stooping, kneeling, crouching or crawling). After adjustment for other factors, there was an elevated risk of knee osteoarthritis at ages 55-64 in jobs that involved higher strength demands (OR 1.88 for each unit increase in grade of strength demand in men, and 3.13 in women) and knee bending (OR 2.45 in men, and 3.49 in women). No corresponding increases in risk were seen at younger ages.

43. Felson *et al* (1991) used data from a longitudinal study in Framingham, USA, to explore the association of knee osteoarthritis during 1983-85 with occupational exposures during 1948-61. As in the report by Anderson *et al*, referred to above, occupations during 1948-61 were classified according to their demands in terms of strength (mainly lifting) and knee bending. In men, after allowance for other factors, the odds ratio for knee osteoarthritis in comparison with employment only in light/sedentary work was 1.07 for work that entailed knee bending, but 2.22 for work that involved both knee bending and strength demands. Corresponding risk estimates for severe osteoarthritis were 1.19 and 1.98.

44. In a Danish cross-sectional survey of floor layers (an occupation that entails frequent kneeling), carpenters, and compositors (Jensen *et al* 2000), a subset of participants were examined radiologically for knee osteoarthritis (classified blind to occupation and symptoms). Among those aged 50 years and over, the estimated prevalences were 34%, 9% and 9% respectively.

45. Lau *et al* (2000) carried out a case-control study of knee osteoarthritis in Hong Kong, and found elevated risks in relation to stair climbing (OR 2.5) and lifting (OR 5.4). No significant association was found with kneeling at work, but the numbers exposed were small.

46. A survey by Schouten *et al* (1992) found high physical workload (squatting, kneeling, lifting, and heavy work) to be associated with lower risks. However, case-control studies by Manninen *et al* (2002), Sandmark *et al* (2000) and Dawson (2003) were more positive, with odds ratios ranging from 1.73 to 4.18 in those with highest exposures (variously defined as daily hours of kneeling/ squatting, or estimated lifetime number of squats, or years of regular kneeling). Additionally in a case-control study by Sahlstrom *et al* (1977), risk of knee osteoarthritis was elevated in subjects exposed to medium or heavy weight-bearing bending of the knee (OR 1.9).

### Meniscal tears

47. Tears of the knee menisci also seem to be associated with higher physical stresses on the knee joint. Thus, in a study of Finnish carpet and floor layers by Kivimaki *et al* (1992), there was a two-fold excess of previous meniscal tear relative to age and sex-matched house painters (10% v 5%); Baker *et al* (2002) found, in a case-control study based on surgical arthroscopy lists, that risk of meniscal tear was raised almost two-fold; and in a parallel investigation, based on a survey of people registered with British general practices, even higher risks of previous menisectomy (OR 2.5) were reported in relation to these activities (Baker *et al* 2003).

## Duration and intensity of exposures

48. As may be seen from the brief summary above, researchers have defined knee-straining exposures in a variety of ways – both qualitatively and quantitatively – sometimes by the daily duration of such work, sometimes by a cumulative index based on years of exposure, or some index of frequency times duration (e.g. total number of squats or knee bends), or sometimes only by job title without further qualification. In particular, Kellgren and Lawrence defined the age-band, but not the mining experience of their study group. Overall, the findings do not provide an exact guide to the variation in risk by intensity of exposure.

49. However, in various studies a rough doubling of risk has been reported after about 10 to 15 years of knee-straining arduous physical activity. In the study by Coggon et al (2000), the relative risk (RR) was 2.3 in those with more than 10 years of kneeling or squatting for more than an hour per day or more than 30 times per day, and 2.9 to 4.2 when squatting was allied with heavy lifting over such an interval; in a study by Dawson *et al*, the RR ranged from

2.7 to 4.2 in men and women with more than 15 years of regular kneeling or squatting; and Sandmark *et al* found a RR in men with at least 10 years of this exposure. The two studies that provide direct evidence in miners (Lawrence *et al* 1952, Greinemann 1997) did not analyse RRs according to length of employment, but in the former study miners were all 40-50 years of age (RR 3) and in the latter cases all had more than 25 years of experience at the coal face (RR 13).

50. The Council sought the opinions of two experts in the field, Professor Coggon and Professor Cooper, on the question of qualifying duration of exposure. Both experts considered that at least 10 years (the period required on average for one progression change in the Kellgren-Lawrence score) was a reasonable estimate.

## Exposure conditions in the mining industry

51. The Council received evidence from various parties (Appendix 1) on circumstances of exposure in the coal mining industry. The following paragraphs summarise the Council's understanding of the situation.

52. In 1947 when the coal industry was nationalised, coal was in heavy demand to support economic recovery from the war. By 1962 the amount mined had risen to 210 million tonnes per year. However, from the 1960s onwards, demand for coal decreased due to the availability of North Sea gas and the decline of traditional manufacturing industries. Following labour disputes in the industry in 1984-5 the majority of mines closed and today only a few deep mines are in operation. Although the UK still uses 62 million tonnes of coal per year, much of this is imported from abroad.

53. Between 1947 and the 1980s the nature of coal production, the working conditions of miners and the numbers with exposure to arduous physical work changed considerably. As a result of an increased drive to produce coal more cost-effectively, there was a gradual switch to mining thicker coal seams; and mechanisation of mining processes was steadily introduced. In particular, extraction and removal of coal on armoured face conveyors replaced the hand winning and filling of coal. In 1947, 60% of the manpower was employed in filling coal and only 2.4% of coal output was won through mechanisation, whereas by the 1970s and 1980s only 15% of the workforce was engaged in these duties and almost all coal was won mechanically.

54. Between the 1940s and the 1960s, miners would normally have spent most of their working careers at the pit face, in jobs that involved kneeling and squatting whilst bearing heavy loads for a large proportion of each day. Face workers had the most physically arduous work, but all mine workers had

relatively strenuous jobs involving kneeling, squatting and lifting heavy loads. Gradually, over several decades, less time was spent by fewer workers in kneeling and squatting under load, although certain tasks still required heavy manual effort while kneeling or squatting. For example, the manual setting of roof supports would have involved lifting 80-85lbs roof bars, sometimes in seams of 0.9m or so; and miners working in thicker seams would still have had to advance box-type roof bars, supported on hydraulic pit props, from a kneeling or squatting position. Although by the 1980s thick seams were mined as standard, before this both thick and thin seams were mined, and thin seams containing profitable anthracite coal continued to be mined. Mining of non-mechanised seams typically required kneeling and squatting under load.

55. Kneeling and squatting under load remained a significant feature of work for most underground miners until the mid-1980s, after which the majority of miners would not have spent prolonged parts of their working day kneeling and squatting.

56. However, such exposures are likely to have persisted for faceworkers and face salvage workers in certain non-mechanised mines until a much later period; and other categories of miner, such as development workers and conveyor belt cleaners and attendants, would have incurred such exposures through activities such as installing track, pipework and conveyor belts, carrying heavy arched supports, and cleaning coal spillages by shovel in circumstances of restricted access. The Council understands that for most miners in these occupational categories, the later cut-off date of 1994 would be more appropriate, but with possible exceptions persisting in private mining industries up to the current time.

## SUMMARY AND EVALUATION OF THE EVIDENCE

57. The main direct evidence on risk of knee osteoarthritis in miners comes from the well-conducted studies of Kellgren and Lawrence and one other study from Germany (paragraphs 25-29). However, a much broader body of evidence implies that risks are increased, and by inference probably more than doubled, among miners. Tears of the menisci have been reported to be more common among miners (paragraph 30), and knee osteoarthritis and meniscal tears more common in workers who engage in activities such as those found in mining that impose frequent physical stress on the knees (paragraph 40).

58. An increased risk of knee osteoarthritis from occupational activities that stress the joint would be compatible with findings when the joints of experimental animals are subjected to unusual physical loading (e.g. Radin *et al* 1982).

59. Several epidemiological studies suggest that risk is particularly high in occupations that entail both kneeling or squatting and heavy lifting (Felson *et al* 1991, Cooper *et al* 1994, Coggon *et al* 2000), with estimates of relative risk of about 2 to 5. This is consistent with the earlier findings of Lawrence (1955) that the prevalence of knee osteoarthritis in miners (even in a cross-sectional survey with possible selection of affected workers out of employment), was 2 to 4 times higher than in comparison occupations.

60. Considered individually, the various studies have potential limitations, such as confounding (e.g. risks might arise from other non-occupational factors, more common in miners); exposure misclassification; biased recall of work activities among those with symptoms; and ascertainment bias (e.g. those in heavy physical work might more readily attend for treatment and so be over-represented among cases recruited through hospitals' surgical lists). But some of these errors and biases favour an under-estimation of risks, and the body of evidence when taken as a whole supports the case for prescription.

61. The Council has received evidence that the qualifying duration of employment in underground mining would need to be at least 10 years in aggregate.

62. In general such exposures should have occurred prior to 1986. However, the service from 1986 of certain categories of coal miner should be equally reckonable – namely, work as a faceworker at non-mechanised coal faces, or as a development worker or conveyor belt cleaner or attendant.

63. Two further issues of difficulty were considered by the Council. The first was the nature and severity of the outcome. The diagnosis of knee osteoarthritis is relatively straight forward and usually supported by objective verifiable radiological evidence of disease. However, such changes become increasingly common with age, and mild degrees of osteoarthritis may be considered a normal finding in the elderly population from whom many claimants would be drawn; under these circumstances risks would no longer be doubled relative to the general population and there could well be little or no assessable disablement in comparison to a person of the same age and sex in those above age 70 with knee OA.

64. In weighing this issue, the Council noted that much of the evidence on doubling of risks came from studies of patients who either had knee joint replacement for their OA or were on hospital waiting lists for knee joint replacement or had knee OA graded at 3 to 4 on the Kellgren-Lawrence scale (a level of severity at which knee joint replacement is often advocated). At the severe end of the spectrum knee osteoarthritis is unquestionably disabling and far from the norm in the elderly population at large. In practice, award of benefit is more likely to fall to claimants with severe disease, thereby addressing the concerns laid out in paragraph 56.

65. A second concern which exercised the Council related to the volume and nature of evidence that mining doubles risks of knee osteoarthritis. Normally, before recommending prescription of a disorder, the Council seeks a reasonably sufficient, robust and consistent body of supporting research evidence; and gives greater weight to direct evidence. The requirement arises because of the error margin in extrapolation and because epidemiological findings tend to vary more than experiments as a result of uncontrolled factors such as biological variation, confounding and bias, which are usually present to a degree even in well-conducted studies. However, as noted before, the case in miners is founded on limited direct evidence in studies of miners, supported by a much larger body of indirect (inferential) evidence.

66. While such evidence might suffice to carry a 'balance of probabilities' argument in civil legal proceedings, in contrast to civil courts the Council has to be mindful beyond the case in hand as to the possible impact of future research. Ideally, the evidence base supporting prescription would be strong enough that new and contrary research findings would not necessitate a change in recommendation: prescription creates a legal entitlement that cannot readily be withdrawn.

67. However, expert evidence indicated that the opportunities for further research on OA knee in miners were strictly limited by the decline in employment in British mines, and would be of marginal relevance given the lower levels of exposure to arduous knee-straining work in modern mining. The Council was persuaded that it need not postpone its recommendation but could deciding according to the data at hand.

68. When the Council last considered disorders of the knee in 1995 (Cm 2842), it recognised, as in this report, research associations between knee osteoarthritis and heavy manual work, repeated physical stress on the knee, and frequent kneeling or squatting under physical loading. It did not recommend prescription as risks were not confirmed as clearly doubled across a range of occupations, and interpretation was "complicated by differences in diagnostic criteria between studies, statistical uncertainties… and lack of information about concomitant non-occupational determinants of disease". Since then, however, the indirect evidence-base (that by activity, although not specifically in coal miners) has grown substantially, while approaches to diagnosis have become more uniform, and the potential for confounding by other risk factors has been more thoroughly addressed. The balance of evidence now favours prescription, given the further evidence provided, for example, by the case-control study by Coggon *et al* in 2000.

**Recommendations**

69. The Council recommends that osteoarthritis of the knee should be prescribed in relation to work as an underground miner for ten years or more in aggregate; but that to be reckonable, any service from 1986 onwards must

be in one or more of the following categories: as (a) a faceworker working non-mechanised coal faces; or as (b) a development worker or conveyor belt cleaner or attendant.

70. A non-mechanised coal face is a face with neither powered roof supports nor a power loader machine which simultaneously cuts and loads the coal.

71. The diagnosis of OA knee for the purposes of the IIDB Scheme should be based on knee pain, swelling, stiffness and restricted movement and if possible x-ray evidence of Stage 3 to 4 on the Kellgren-Lawrence scale; but should also be accepted in those who are on a surgical waiting list for knee replacement or have had a knee replacement previously.

| **Prescribed disease** | **Occupation** |
|---|---|
| **A14** Osteoarthritis of the knee | Work for ten years or more in aggregate in any combination of the following coal mining occupations:<br>(a) Before 1986, as an underground coal miner; or<br>(b) After 1985, as:<br>(i) a faceworker working non-mechanised coal faces; or<br>(ii) a development worker or conveyor belt cleaner or attendant.<br>A non-mechanised coal face is a face with neither powered roof supports nor a power loader machine which simultaneously cuts and loads the coal. |

## APPENDIX 1

Consultations with individuals and experts

Health and Safety Executive
National Union of Mineworkers
UK Coal
British Association of Colliery Management
Union of Democratic Mineworkers
Mr Clifford Jones
Federation of Small Mines
Institute of Occupational Medicine

## APPENDIX 2

### Kellgren-Lawrence scale

| Grade | Comments |
|---|---|
| 0 | No radiographic findings of osteoarthritis |
| 1 | Minute osteophytes of doubtful clinical significance |
| 2 | Definite osteophytes with unimpaired joint space |
| 3 | Definite osteophytes with moderate joint space narrowing |
| 4 | Definite osteophytes with severe joint space narrowing and subchondral sclerosis |

Printed in the UK by The Stationery Office Limited
on behalf of the Controller of Her Majesty's Stationery Office
ID5890140 407137 08/08 19585

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Published by TSO (The Stationery Office) and available from:

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ISBN 978-0-10-174402-7